REMARKS

By this amendment, the specification has been editorially amended, claims 13, 16-22, 29 and 35-44 have been canceled, claims 1, 3, 5, 9-11, 14, 23-27 and 30-34 have been amended and new claims 45-56 have been added to the application. Currently, claims 1-12, 14-15, 23-28, 30-34 and 45-56 are pending in the application.

Examiner Teresinski and SPE Le are thanked for the courtesies extended to the undersigned during the personal interview on December 18, 2003. During the interview, the invention was discussed along with the cited references to Cugini et al., Fujii et al. and Cole, Jr. et al. Proposed claim amendments were also discussed especially focusing on two versions of amendments to claim 1 to clarify the structure of the electric circuit that is formed during testing. Additional discussion included potentially amending the claims to recite the probe connection as shown in the figures since Cugini et al. did not provide any connections to the circuit board.

Applicants have attempted to simplify the issues in this

application by reducing the number of independent claims from 12 to 5. Further, applicants have amended the claims so that they include the probe that can contact terminals on the circuit board. Applicants have also deleted a total of 19 claims from the application. Applicants have also added new claims 45-56 in this amendment; however, independent claim 45 is similar to claim 1. Claim 1 focuses on testing for an open circuit and claim 45 focuses on testing for a short circuit. Also, dependent claims 46-56 correspond to dependent claims 2-11 and original claim 13, respectively. Applicants respectfully submit that the specification changes and the claim changes place the application in condition for allowance.

Claims 1-8, 10-15, 17-19, 21, 23-34 and 38-44 were rejected under 35 USC 102(e) as being anticipated by Cugini et al. Claims 9, 20 and 22 were rejected under 35 USC 103(a) as being obvious over Cugini et al. in view of Fujii et al. Claims 16, 35 and 36 were rejected under 35 USC 103(a) as being obvious over Cugini et al. in view of Cole, Jr. et al. Claim 37 was rejected under 35 USC 103(a) as being obvious over Cugini te al. and Cole, Jr. et al. and further in view of Fujii et al. These rejections are respectfully traversed in view of the amendments to the claims

and the following remarks.

The present invention relates to a circuit board testing apparatus and method for testing an electric state such as continuity, open-circuit, short-circuit, in a number of wirings formed on a circuit board.

In the present invention, as shown for example in Fig. 1, the circuit board testing device comprises an upper fixture unit 50 that includes a cap-like housing which is so configured as to cover a certain region on one surface of the work 10. The housing includes a plate electrode 51 made of a transparent electrode and shielding members 52 made of, e.g., a rubber. The upper fixture unit 50 is movable toward and away from the work 10 as an integral unit.

A transparent electrode is used as the plate electrode 51. An electromagnetic wave can be irradiated onto the pad portion of the target wiring even if the plate electrode 51 is provided high above the target wiring because the electromagnetic wave passes through the transparent electrode 51 and is irradiated onto the pad portion. In view of the above, in this embodiment, the plate electrode 51 can be disposed closer to the pad portion 121a of the target wiring 121, and electrons discharged from the pad

portion 121a upon irradiation can be securely trapped by the plate electrode 51 to thereby secure a more stable test.

The electromagnetic wave irradiator 60 irradiates an electromagnetic wave L which, in turn, is projected onto the pad portion 12a of the target wiring, to thereby discharge electrons from the surface of the pad portion 12a due to photoelectric effect. The discharged electrons are electrically attracted by the plate electrode 51 aided by the voltage applied thereto. This arrangement eliminates a likelihood that electrons discharged once may be returned to the pad portion or dispersed to the other pad portion(s), or form a spatial region of electric charges, as occurred in the conventional arrangement.

A current detecting section 90 is provided in a conductive circuit pathway through which a current runs from one terminal of the power source 80 to the opposite terminal thereof via the plate electrode 51 and the target wiring to detect the current running in the circuit pathway. Specifically, the plus terminal of the power source 80 is electrically connected to the plate electrode 51. The minus terminal of the power source 80 is connected to one terminal of the multiplexer 42 via the current detecting section 90, while the opposite terminal of the

multiplexer 42 is connected to a number of probes 41 which are in contact with respective corresponding terminals 12b of the wirings 12.

Claim 1 has been amended to recite "a voltage supplier operatively connected between the electrode and the second terminal of the selected wiring to apply voltage therebetween so that the electrode has a higher potential than the second terminal of the selected wiring, the voltage supplier including a probe operatively connected to the voltage supplier and connectable to the second terminal of the selected wiring; a current detector which detects an electric current that passes through the electrode, the probe and the second terminal of the selected wiring; and a judger which determines existence of an open-circuit in the selected wiring based on the current detected by the current detector".

Independent claim 14 has been similarly amended to recite "a voltage supplier including a probe operatively connected to the voltage supplier and connectable to at least one of the second terminals of the wirings, the voltage supplier being operatively connected between the electrode and the at least one of the second terminals to apply voltage therebetween so that the

electrode has a higher potential than the at least one of the second terminals; a current detector which detects an electric current that passes through the electrode, the probe and the at least one of the second terminals; and a judger which determines existence of an open-circuit and/or a short-circuit in at least one of the wirings based on the current detected by the current detector".

Independent claim 23 has been similarly amended to recite "a voltage supplier including a probe operatively connected to the voltage supplier and connectable to at least one of the second terminals of the wirings, the voltage supplier operatively connected between the electrode and the at least one of the second terminals to apply voltage therebetween so that the electrode has a higher potential than the at least one of the second terminals; a current detector which detects an electric current that passes through the electrode, the probe, and the at least one of the second terminals; and a judger which judges continuity and/or a short-circuit in at least one of the wirings based on the electric current detected by the current detector.

Independent method claim 30 has been amended to recite "providing an electrode operatively connected to a probe which is

selectively connectable to at least one of the second terminals; irradiating at least one of the first terminals of the wirings with an electromagnetic wave to discharge electrons from the at least one of the first terminals into a space by photoelectric effect; trapping discharged electrons by the electrode having a potential higher than at least one of the second terminals of the wirings and allowing a current caused by trapped electrons to flow through the electrode, the probe and the at least one of the second terminals; detecting the current that flows through the electrode, the probe and the at least one of the second terminals; and judging continuity and/or a short-circuit in at least one of the wirings based on the current flowing through the wiring".

New independent claim 45 recites "a voltage supplier operatively connected between the electrode and a second terminal of a second selected wiring to apply voltage therebetween so that the electrode has a higher potential than the second terminal of the second selected wiring, the voltage supplier including a probe operatively connected to the voltage supplier and connectable to the second terminal of the second selected wiring; a current detector which detects an electric current that passes

through the electrode, the probe and the second terminal of the second selected wiring; and a judger which determines existence of a short-circuit in the first selected wiring based on the current detected by the current detector".

These features stated above, such as the voltage supplier including a probe and the current detector that detects an electric current that passes through the electrode, the probe and the second terminal are not shown or suggested by Cugini et al. and the other references of record.

Cugini et al. relate to testing electrical traces, such as on a circuit board, for characteristics such as opens, shorts, neck-downs, or improper etching; and it more specifically relates to a test method using a photoelectric effect.

Cugini et al. disclose that a substrate 80, such as printed circuit board 80P having an upper side 81U and a lower side 81L, contains electrical traces 85 to be tested. Cugini et al. also disclose that an electromagnetic source means 20 generally comprises a source of electromagnetic radiation 21, such as ultraviolet laser 22. Cugini et al. also disclose that a vacuum chamber means 12 that includes: a chamber 12C enclosing a test volume 13; an evacuation means, such as a vacuum pump 14 for

lowering the pressure in the test volume 13.

Cugini et al. also disclose that electrode electronics 55U, 55L provide voltages to electrodes 51U, 51L on lines 56U, 56L respectively as well as analyze currents through electrodes 51, such as with ammeters 59U, 59L.

Cugini et al. also disclose that a first location on the trace 85, such as on upper end pad 87EU, is interrogated by beam 24U. This charges the first location to a voltage level equal to that of the upper collector 51C. When this voltage level has been achieved as best evidenced by no further current flow between trace 85 and collector 51C, beam 24U or 24L is then directed to another location, such as opposite end pad 87EL of trace 85. If the second end point is charged, to the same voltage level such that no current is detected, then it may be assumed that continuity exists between the first and second locations. Conversely, if a current is detected then the second location does not exhibit a charge level equal to that of collector 51C and it may be assumed that an open circuit has been detected and the system will display and/or record this as a defect. Each trace 85 is tested for continuity in this manner. The test for shorts is performed in a manner similar to that

described above for determining continuity or open circuits.

Cugini et al. do not disclose the voltage supplier including a probe as well as the current detector and judger as claimed in independent claims 1, 14, 23, 30 and 45.

Applicants respectfully state that Cugini et al. is different from the present invention in the principle of detecting the open circuit and/or short-circuit of wirings. Applicants point out that Cugini et al. disclose that a test is made without physical contact of electrical traces with the tester (see for example claims 1, 6 and 10 in Cugini et al.). Prior to measurement or testing, a circuit board is initialized to pre-charge trances thereon to a known voltage (see column 4 line 62 to column 5 line 11. The method of initialization is disclosed in column 5, line 12 though column 6, line 4).

Applicants also point out that Cugini et al. do not detect current running through the trace. On the other hand, the present invention disclose that a voltage supplier produces a difference of electric potential between the electrode and the second terminal so that the electrode portion has an electrical potential higher than that of the second terminal. Further, a probe is connectable to the second terminal and a current

detector detects a current that passes through the electrode, the probe and the second terminal.

Applicants also point out that the trace in Cugini et al. is not connected with the tester. The present invention also recites that the voltage supplier includes a power source, and the probe includes a connector which electrically connects the power source, the electrode, the second terminal, and the current detector with one another to thereby constitute a closed circuit including the space between the electrode and the first terminal of the selected wiring through which the discharged electron flows as recited in claim 3.

Applicants also point out that Cugini et al. do not disclose any probe to be brought into contact with the trace which according to Cugini et al. is free from the tester.

Applicants also point out that Cugini et al. disclose that an ultra-violet laser illuminates the individual trace 85T. However, collective illumination in Cugini et al. is for the purpose of initialization of the traces (see column 5, line 54 to column 6, line 4). On the other hand, collective irradiation in the present invention is to discharge electrons from the wirings and to test open-circuits and short-circuits in the wiring

connected to the electrode which traps the discharged electrons.

Applicants submit that Fujii et al. do not make up for the deficiencies in Cugini et al.

Fujii et al. relate to a voltage & displacement measuring apparatus and its probe for measuring the position and voltage of a micro structure such as a wiring on a semiconductor chip.

Fujii et al. disclose that Fig. 16 shows an axial sectional view of the lower portion of the voltage and displacement sensitive probe 30E in the sixth embodiment. This lower portion applies a photoconductive gate and is symmetrical, excluding the lead wire 85, with respect to any plane through the axis thereof.

Fujii et al. also disclose that an electric current that corresponds to the voltage between the probing needle 34B and the electrically conductive transparent film 32C flows in the lead wire 85 to be detected by the current detection circuit 112.

Fujii et al. do not disclose the voltage supplier including a probe as well as the current detector and judger as claimed in independent claims 1, 14, 23, 30 and 45.

Applicants respectfully point out that the layer 85 in Fujii et al. does not have the function of trapping the discharged electrons. Applicants also believe that none of the references

disclose nor teach that the wiring on the circuit board under test is used as the electrode to trap the discharged electrons and the connection of the wiring with the power source for that purpose.

It is therefore respectfully submitted that both Cugini et al. and Fujii et al., individually or in combination, do not disclose or suggest the presently claimed invention and it would not have been obvious to one of ordinary skill in the art to combine these references to render the present claims obvious.

Applicants submit that Cole, Jr. et al. also do not make up for the deficiencies in Cugini et al.

Cole, Jr. et al. relate to testing and failure analysis methods using an electron beam and more particularly to an electron beam apparatus and method for identifying and mapping a conduction state of one or more electrical conductors located beneath an insulating layer in a circuit such as an integrated circuit, a multi-chip module, a printed-circuit board, a flexible printed circuit or the like.

Cole, Jr. et al. disclose that the apparatus 10 comprises a stage 12 for holding a circuit 100 and making one or more electrical connections thereto; an electron source 14 for

providing an electron beam 16 incident on an outer surface 102 of the circuit 100 for generating an electrical potential thereon.

Cole, Jr. et al. also disclose that the electron beam irradiating the outer surface 102 of the insulating layer 104 produces both backscattered electrons (not shown) and secondary electrons 32. The secondary electrons 32 generally have a low energy in the range of about 2-5 eV. and are emitted at a rate that depends on the energy of the incident electron beam 16. This is due to a carrying penetration depth in the dielectric material forming the insulating layer 104 with the energy of the electron beam 16; and it is further due to the low energy of the secondary electrons 32 which permits only those secondary electrons 32 generated within a few nanometers of the outer surface 102 to escape from the insulating layer 104.

Cole, Jr. et al. also disclose that the electrical connections 26 can further penetrate the high-vacuum chamber 24 for connection to the measuring circuitry 18 which is generally located outside the high-vacuum chamber 24. The stage 12 can also provide for a positioning the circuit in directions perpendicular to an incident electron beam 16 or for orienting the circuit 100 at an angle with respect to the incident beam 16.

Cole, Jr. et al. do not disclose the voltage supplier including a probe as well as the current detector and judger as claimed in independent claims 1, 14, 23, 30 and 45.

Applicants respectfully believe that Cole, Jr. et al. is different from Cugini et al. in which an exposed trace is irradiated by electromagnetic wave such as ultra-violet laser beam, with the circuit board under test does not have any contact with the tester. In Cole, Jr. et al., the circuit under test is connected with a measuring circuitry 18 through connections 26.

The basic theory of measurement is quite different between Cole, Jr. et al. and Cugini et al. Thus, applicants respectfully submit that no motivation exists in combining Cole, Jr. et al. and Cugini et al. Further, the basic theory of measurement of the present invention is also different from Cole, Jr. et al. and Cugini et al.

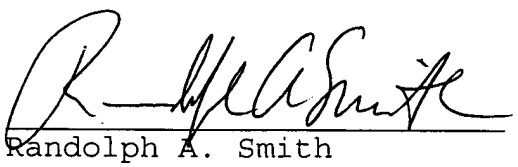
It is further respectfully submitted that Cugini et al., Cole, Jr. et al. and Fujii et al. individually or in combination, do not disclose or suggest the presently claimed invention and it would not have been obvious to one of ordinary skill in the art to combine these references to render the present claims obvious. Also, there is no teaching or suggestion in these references for

combining one or more of them. Accordingly, claims 1-12, 14-15, 23-28, 30-34 and 45-56 clearly define over the prior art of record and should be allowed.

In view of foregoing claim amendments and remarks, it is respectfully submitted that the application is now in condition for allowance and an action to this effect is respectfully requested.

If there are any questions or concerns regarding the amendments or these remarks, the Examiner is requested to telephone the undersigned at the telephone number listed below.

Respectfully submitted,



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